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tion is the same, whether the bulb is placed at 6 cm. or 6 m. from the fog-chamber. But only in the former case ($D = 6$ cm.) is the effect cumulative; only for very short distances will persistent or large nuclei appear if the exposure is prolonged several minutes. I have, therefore, suspected that the radiation from the X-ray bulb is twofold in character, that the instantaneous effect (fleeting nuclei) is due to a gamma-like ray quick-moving enough to penetrate several millimeters of iron plate appreciably even for $D = 6$ meters; furthermore, that the cumulative effect (persistent nuclei) is due to X-light properly so called, which produces the usual effects subject to the law of inverse squares.

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*THE BIOLOGICAL LABORATORY OF THE
BUREAU OF FISHERIES AT WOODS
HOLE, MASS. REPORT OF WORK
FOR THE SUMMER OF 1904.**

THE laboratory was opened to investigators on the fifteenth of June, and continued in operation until near the close of September. During the whole or a part of this period twenty-eight investigators were engaged in work upon problems of marine biology. A brief statement of the special subjects of research will be given below.

I. EQUIPMENT, STAFF, ETC.

The same portions of the station were occupied as during the preceding season, and need not again be detailed; the steam vessels *Fish Hawk*, *Phalarope* and *Blue Wing* were in service during the whole or a part of the season; the zoological library of Brown University was again generously placed at the disposal of the laboratory. Two fish pounds were set, one being placed, as formerly, in Buzzards Bay, not far from

* Report to the Commissioner of Fisheries by the director of the laboratory.

the station, the other being planted at No Mans Land, a small island a few miles to the south of Marthas Vineyard. Here a camp was located, several assistants being detailed to tend the trap for a period of about seven weeks.

The staff of the laboratory, for the past season, consisted of a director and seventeen assistants, together with a matron, two janitors and a chambermaid. To this list should be added a clerk and a collector, permanently attached to the station, and the crews of the various vessels. Of the assistants, three had immediate supervision of certain branches of the survey work; three others had charge respectively of the library, the supply room and the fish traps; while the remaining eleven rendered various services in the laboratory or in the field. Mention should also be made here of seven salaried investigators, employed by the bureau to conduct independent researches.

The plan of having a 'seminar' or research club, for the discussion of work in progress at the laboratory, was successfully continued, some of the meetings being largely attended by outsiders, as well as by investigators at the station.

II. BIOLOGICAL SURVEY.

The biological survey of the neighboring waters, commenced during the preceding season, was actively continued. The *Fish Hawk* was at the disposal of the laboratory for some five weeks, during which period she was chiefly engaged in dredging work in Buzzards Bay. In all 66 'stations' were dredged by this vessel, these being located at regular intervals over the bottom of the entire bay. The supervision of this branch of the work was intrusted to Mr. Leon J. Cole. Dredging in Vineyard Sound was likewise continued. A number of the stations (18) of the preceding year were again located and dredged, but the principal work

in the sound was done in the shallower waters near shore. Here the *Phalarope* was employed on account of her lighter draught. This vessel was specially equipped for the purpose at the commencement of the season; a large movable platform being built and a derrick erected. Mr. R. C. Osburn supervised, for the most part, the dredging operations of the *Phalarope*. Seventy-seven 'stations' were dredged, completing the coast line of Vineyard Sound, upon both sides. Dr. Bradley M. Davis, assisted by Miss Lillian MacRae, directed the collecting and identifying of the botanical material secured.

Systematic records were of course kept of all species found in the dredge. As far as possible, identifications were made in the field or in the laboratory, but much material was preserved for reference to specialists. During the preceding winter, many of the species taken during the summer of 1903 had been determined by various experts, and this collection has now been added to the laboratory's museum of local fauna, where it has already proved to be of great assistance in the task of identifying new material. Thanks are due to the following zoologists for the identification of the 1903 material: Professor C. C. Nutting (hydrozoa), Dr. W. R. Coe (nemerteans), Dr. J. P. Moore (annelids), Professor H. L. Clark (echinoderms), Dr. S. J. Holmes (amphipods), Dr. A. E. Ortmann (schizopods), Dr. Harriet Richardson (isopods), Dr. B. W. Evermann (fishes); and to the staff of the U. S. National Museum, for the determination of the molluses and of several groups of crustacea. The task of identifying the tunicates has been undertaken by Professor W. E. Ritter, the barnacles by Professor M. A. Bigelow, and the bryozoa by Miss Alice Robertson. Thus far it has not been found possible to make any satisfactory disposition of the sponges.

As usual much general collecting was carried on by Mr. Vinal Edwards and others, the material thus obtained being turned over to investigators at the laboratory or preserved for future determination. Mr. Edwards kept his customary records of the fishes taken by trap or by seine.

During the present winter the task of compiling the results of the past two summers' dredging has been undertaken. The first step in this work consists in tabulating the distribution of each species by stations, and in plotting out these distribution areas upon suitable charts. By authorization of the commissioner, Mr. Chas. V. Morrill, of Columbia University, has been engaged to carry out this work, and a map will shortly be printed depicting the coast line of Vineyard Sound and Buzzards Bay, together with the dredging stations established therein, but lacking other details. It is intended that the distribution of each of the more important species shall be plotted upon a separate copy of this map.

Another chart, representing on a minute-scale the topography of a small group of partially submerged rocks in Woods Harbor was constructed by Mr. F. W. Cushwa, under the direction of Dr. Davis. Printed copies of this chart will be employed for portraying annual and seasonal fluctuations in the distribution of various forms of marine life, particularly algae.

III. CARD CATALOGUE RECORD OF LOCAL FAUNA AND FLORA.

Work upon this record has likewise been continued actively. During the spring of 1904 the notes hitherto abstracted from various sources were transferred in type-writing to catalogue cards, according to the system already described.* In all, 1,146 species were thus recorded, and upwards of 5,000 cards employed. The cata-

* SCIENCE, February 12, 1904.

logue, even in its present condition, has already proved its usefulness.

During the summer, Messrs. Max Morse, D. W. Davis and some of the other assistants completed, as far as was then practicable, the search for published data. The *Reports* and *Bulletins* of the U. S. Fish Commission, the *Transactions of the Connecticut Academy of Sciences*, the *Biological Bulletin*, the *American Naturalist* and the *Journal of Morphology*, together with the large collection of reprints contained in the library at the station, were systematically searched, and all relevant facts, even incidental references to the ecology of local species, were recorded. In all 84 papers were found to contain information of the sort desired, in addition to those abstracted during the preceding year.

There must also be mentioned a most valuable set of 113 cards in possession of the Marine Biological Laboratory, and kindly loaned by Dr. F. R. Lillie for incorporation into the present catalogue system. These cards record personal observations by various well-known investigators who have been connected with the Marine Biological Laboratory in past years. In addition, several zoologists generously prepared during the summer extensive sets of notes upon groups to which they had given especial attention. Mr. Lynds Jones furnished data relating to 104 species of marine and shore birds of the neighborhood; Professor Chas. B. Wilson furnished a set dealing with fifty species of parasitic copepods; Dr. W. R. Coe contributed notes relating to 32 local nemerteans and Dr. J. P. Moore prepared records of 25 species of polychæta. In addition valuable notes were received from Dr. A. L. Treadwell and Dr. Louis Murbach, dealing with polychæta and medusæ respectively.

It is needless to add that the data derived from the collecting work in progress

will be incorporated as soon as they are made available.

IV. INDIVIDUAL INVESTIGATIONS.

Robert L. Baird, assistant in zoology and geology, Oberlin College, carried on experiments in the endeavor to determine the presence of sense of smell in *Fundulus*, to differentiate that sense from the sense of taste, and to ascertain the importance of the sense of smell to the fish in its life habits, especially in obtaining food.

E. N. Carter, superintendent U. S. Fisheries Station, St. Johnsbury, Vt., commenced experiments with view to testing the effect of temperature at the time of fertilization upon the subsequent development of fish eggs.

Leon J. Cole, Austin teaching fellow in zoology, Harvard University, assisted in the work of the biological survey, having supervision of the dredging operations of the *Fish Hawk* in Buzzards Bay.

Winterton C. Curtis, Ph.D., assistant professor of zoology, University of Missouri, was employed by the bureau to conduct experiments with a view to determining the life history of certain parasites of fishes. The attempt was made to find some treatment by which the 'sand shark,' *Carcharias littoralis*, could be freed of the cestode *Crosobothrium laciniatum*, which with rare exceptions infests the spiral valve of this fish. The 'oil of male fern,' commonly used as a vermifuge in veterinary and human practise, was tried and proved quite effective. In all some 56 sharks were subjected to the treatment with this drug and of these there were 38 survivors, of which 26 were without any infection, the remaining 12 being infected with *C. laciniatum* in much smaller numbers than one would expect to find in any untreated specimens. The 18 non-surviving specimens, of which some were killed because they seemed to be

dying, and others were examined soon after death from the treatment, showed evidence that all of the parasites had been killed by the drug before the death of the host. The best results in expurgation came from those cases in which the dose had been repeated after an interval of several days, but as this method was not perfected until late in the summer, it was impossible to apply it to more than a limited number of specimens. Hence these results do little beyond indicating that some continuation of the experiments will be necessary in order to determine a mode of treatment effective enough for practical use in expurgating sharks for experiments in artificial infection.

Infection experiments were carried out during 1903 and 1904 to find out what cestode develops from the *Scolex polymorphus* of the 'squateague' (*Cynoscion regalis*), when these larvæ are fed to the sand shark. Each year a number of the sharks thus infected were found to contain large number of young *Phoreibothrium triloculatum* Linton, a cestode which is recorded from the 'dusky shark' (*Carcharhinus obscurus*). Some evidence was obtained pointing to the conclusion that *Scolex polymorphus* likewise comprises larvæ which develop into the genus *Crossobothrium*, but this evidence is so inconclusive that it can have no value unless strongly confirmed by the results of further investigation.

Bradley M. Davis, Ph.D., assistant professor of botany, University of Chicago, supervised the collecting and identifying of marine algae in connection with the dredging work, being assisted in this task by Miss L. J. MacRae. Dr. Davis likewise commenced the compilation of a set of records of the marine plants of this region to be incorporated into the catalogue of local marine fauna and flora.

Donald W. Davis, student in Harvard

University, assisted in the survey work, as well as in certain experiments with fishes to be described below.

Irving A. Field, Thayer Scholar, Harvard University, continued, as salaried assistant, his studies of the food of fishes of little or no food value, adding to the list of those investigated during the preceding summer the 'horned dog-fish' (*Squalus acanthias*), and the 'sand shark' (*Carcharias littoralis*). Experiments with view to determining the food value of the common dog-fish, and to discovering other possible economic uses, were likewise continued.

Frederic P. Gorham, Ph.D., associate professor of biology, Brown University, conducted, on behalf of the bureau, (1) bacteriological studies upon an epidemic disease of the menhaden then prevalent in Narragansett Bay and in certain parts of Buzzards Bay; (2) experiments, continued from the preceding year, upon the effects of various sorts of metal piping upon marine organisms kept in aquaria; (3) studies of certain properties of the blood of various marine animals.

Clarence W. Hahn, A.M., teacher of biology, New York High School of Commerce, carried on experiments upon the regeneration of *Holocampa*, *Metridium* and *Sagartia*, with view to discovering the causes that determine the growth of the directive mesenteries. Time was also spent in collaborating results already obtained on this subject.

Lynds Jones, M.S., instructor in zoology, Oberlin College, continued his studies upon the food of marine birds. The living birds were closely observed in their natural habitat, their method of fishing and of feeding their young being studied. The various local nesting grounds of the terns and gulls were visited, nine days being spent on Muskeget Island. Young gulls

and terns were brought back and studied in confinement for some weeks.

B. W. Kunkel, graduate student, Yale University, collected and carried on a preliminary study of the brains of eighteen species of elasmobranchs and teleosts of the locality, devoting his principal attention to the epiphysis.

Edwin Linton, Ph.D., professor of biology, Washington and Jefferson College, was engaged, on behalf of the bureau, (1) in working over a collection of entozoa from fish and fish-eating birds made by Mr. Vinal Edwards from September, 1903, to June, 1904, and contained in 300 vials; (2) in working over material collected during the current season by himself and an assistant, special attention being devoted to certain cestode parasites which were found in great numbers in the butter-fish (*Rhombus triacanthus*).

Lillian J. MacRae, teacher in South Boston High School, assisted Dr. Davis in the work of collecting and identifying marine algae.

W. J. Moenkhaus, Ph.D., associate professor of physiology, Indiana University, repeated certain experiments of previous years in order to obtain material for further study of the behavior of chromatin in hybrids. The following crosses were made: (1) *Fundulus heteroclitus* ♀ × *Gasterosteus bispinosus* ♂, (2) *Fundulus heteroclitus* ♀ × *Stenotomus chrysops* ♂, (3) *Fundulus majalis* ♀ × *F. heteroclitus* ♂, (4) *Fundulus majalis* ♀ × *Tautogolabrus adspersus* ♂. An attempt to fertilize *Fundulus* eggs with the sperm of *Opsanus tau* was unsuccessful.

J. Percy Moore, Ph.D., instructor in zoology, University of Pennsylvania, made considerable progress with the synopsis of annelids of the Woods Hole region which he is engaged in preparing on behalf of

the bureau, completing the families of Polynoidæ and Nereidæ, and drafting descriptions of species belonging to other families. The determination of the relations of the various sexual phases of the species of the latter family being a matter of considerable difficulty, the collection of suitable material for this purpose consumed much time. The life history of *Platynereis megalops* proved to be quite as complex as that of the classical *P. Dumerilii*, presenting, however, some important differences. With the exception of *Nereis arenaceodentata*, heteronereids of all the species have been found. An additional new species of *Nereis* was also discovered. The Polynoidæ and other scaly polychæta are of well-known species, though several new to the region have been found. The large felted polychæta, commonly called the 'sea mouse,' of American waters, has always been identified with the European *Aphrodite aculeata*. A careful study of specimens taken off Nantucket and Marthas Vineyard show that the species occurring there is quite distinct. The dredging operations connected with the biological survey resulted in large collections of polychæta, the determination and recording of which required much time. Besides adding several forms to the known fauna of the region, the most interesting of which is the remarkable *Spiochætopterus oculatus*, this work has added greatly to our knowledge of the local distribution of certain species.

Max Morse, fellow in zoology, Columbia University, assisted in the work of the biological survey, as well as in biometric studies carried on by Dr. Sumner.

Raymond C. Osburn, teacher of biology, New York High School of Commerce, assisted in the work of the biological survey, having supervision of the dredging operations of the *Phalarope*.

George H. Parker, Ph.D., assistant professor of zoology, Harvard University, continued, as salaried investigator, his experiments of a previous summer upon the hearing of fishes, devoting especial attention to the functions of the ear of the squeateague (*Cynoscion regalis*). The latter consists of a dorsal utriculus, with three semi-circular canals, and of ventral sacculus containing a large otolith. The cavity of the utriculus does not communicate with that of the sacculus; hence the ear of this fish, unlike that of most vertebrates, is represented anatomically by two separate parts. When the utriculi and their appended semi-circular canals and nerves were cut, the fishes showed characteristic disturbances in their equilibrium, and these disturbances persisted till death. Such fishes were as responsive as normal ones to sound vibrations produced by tapping with a mallet on the side of the wooden aquarium in which they were kept. When the otoliths, which are normally quite freely movable in the sacci, were pressed by means of pins against the outer, non-nervous sides of their chambers and were thus fastened, the fishes showed no disturbance of equilibrium, but did not react to sound vibrations as do normal fishes. It, therefore seems probable to Dr. Parker that the utriculus and the semicircular canals are sense organs concerned with equilibrium, and that the sacculus with its contained otolith is an organ of hearing.

Henry F. Perkins, instructor in zoology, University of Vermont, and Carnegie research assistant, continued his endeavors to rear the eggs of *Gonionemus murbachii*, with view to a study of the embryology of this form. This task has proved extremely difficult in the past, but preliminary steps were successfully taken. Towing collections of various hydromedusæ were also made from the wharf, furnishing material

for a study of the formation of new tentacles.

L. Charles Raiford, instructor in chemistry and dyeing, Mississippi Agricultural College, carried on studies upon the intestinal bacteria of certain fishes. Cultures were taken from 57 dog-fish and 26 menhaden, and those organisms which appeared to be of constant occurrence were isolated in pure culture. So far as his work has been carried, Mr. Raiford believes that all of the bacteria found are commonly known species.

H. W. Rand, Ph.D., instructor in zoology, Harvard University, collected and prepared material for studies of the venous system of the skate. Injections were made of the hepatic portal, cardinal and lateral veins, with a view to determining the relations and connections of these several systems of veins in the posterior region of the abdominal cavity. Dr. Rand also made a series of observations on the respiratory movements of the skate, with special reference to the functions of the spiracle.

George G. Scott, M.A., tutor in philosophy, College of the City of New York, and assistant in charge of the supply room at the laboratory, carried on studies upon the sporozoa parasitic in various marine invertebrates.

Grant Smith, Ph.D., teacher of biology, Chicago Normal School, collected and prepared material for the study of the eyes of various marine invertebrates.

W. L. Sperry, Rhodes scholar elect, carried on studies upon the muscular and nervous systems of the star-fish, *Asterias forbesi*. In this work Mr. Sperry assisted Professor H. L. Clark, who, however, was not himself present this season. Certain features of the musculature were studied in detail and drawn, observations upon the movements of the living animal were made,

and experiments were made to determine suitable methods of staining.

M. X. Sullivan, Ph.D., instructor in chemical physiology, Brown University, investigated the physiology of digestion in the common dog-fish.

Francis Bertody Sumner, Ph.D., instructor in zoology, College of the City of New York, and director of the laboratory, was occupied with (1) work upon the biological survey of the marine fauna and flora of the vicinity of Woods Hole (*see above*), (2) the card catalogue record of local species (*see above*), (3) experimental and statistical studies of various fishes with reference to adaption and selection. In the experimental part of this work, Dr. Sumner was assisted by Mr. D. W. Davis, in the biometric part by Messrs. Davis, Metcalf, Morse and some other assistants.

E. E. Watson, student in Iowa University, was engaged in biometric studies of various local crabs.

Chas. B. Wilson, A.M., professor of biology, State Normal School, Westfield, Mass., carried on studies of parasitic copepods, both living and preserved material being used. Many interesting facts relating to the ecology of these parasites, some of possible economic value, were discovered. In a number of cases the life history was traced partially or completely. A considerable number of new species were found. Professor Wilson likewise prepared an extensive set of records of local parasitic copepods for incorporation into the faunal catalogue.

Commissioner G. M. Bowers, Dr. B. W. Evermann, chief of the Division of Scientific Inquiry, and Mr. E. L. Goldsborough, assistant in that division, likewise spent portions of the summer at the station; and the hospitality of the laboratory was extended to Mr. Chas. R. Knight, the well-

known animal painter, and to Mr. S. F. Denton, the illustrator and taxidermist.

FRANCIS B. SUMNER.

ALBATROSS EXPEDITION TO THE EASTERN
PACIFIC.*

II.

WE left Callao for Easter Island Saturday afternoon, December 3; as far as 90° west longitude we remained in the Humboldt current, as we could readily see from the character of the temperature serials and from the amount of pelagic life we obtained from both the surface and the intermediate hauls. This current also affected the bottom fauna, which was fairly rich even as far as 800 miles from the shore while we remained within the limits of the northern current. As soon as we ran outside of this the character of the surface fauna changed; it became less and less abundant as we made our way to Easter Island, the western half of the line from Callao becoming gradually barren. This current also affected the deep-sea fauna to such an extent that towards Easter Island, at a distance of 1,200 to 1,400 miles from the South American continent, our trawl hauls were absolutely barren; the bottom for the greater part of the line was covered with manganese nodules on which were found attached a few insignificant siliceous sponges, an occasional ophiuran, and a few brachiopods or diminutive worm tubes, the same bottom continuing to Sala y Gomez and between there and Easter Island. Sala y Gomez and Easter Island are connected by a ridge, on which we found 1,142 fathoms near Sala y Gomez, and 1,696 fathoms between that point and Easter Island. The ridge rises rapidly from about 2,000 fathoms, the general oceanic depth within about

* Extract from a letter of Mr. Alexander Agassiz to Hon. George M. Bowers, U. S. Fish Commissioner, dated Chatham Island, Galapagos, January 6, 1905.